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OF
THE ROYAL ASTRONOMICAL SOCIETY
OF CANADA

DEVOTED TO THE ADVANCEMENT OF ASTRONOMY AND ALLIED SCIENCES

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PLATE XII.

AMERICAN ASTRONOMICAL SOCIETY MEETING AT CAMBRIDGE, MASS., AUGUST 20, 1918

F. Henroteau	Alice H. Farnsworth	Benjamin Boss	Henrietta S. Leavitt	A. Estelle Glancy	A. E. Douglass
E. C. Phillips	Elizabeth L. Williams	Margaret Harwood	Mrs. Stetson	Susan Raymond	Louis Rodés
R. E. DeLury	Dorothy W. Block	Annie J. Cannon	Mrs. Percival Lowell	Sarah F. Whiting	R. W. Willson
W. I. Milham	L. A. Brigham	E. D. Roe	Margaretta Palmer	Ida Barney	F. W. Very
S. Albrecht	C. E. Kelly	S. A. Mitchell	Asaph Hall	E. S. King	Leon Campbell
J. N. Poor	Jesse Pawling	Mrs. Roe	Antonia C. Maury	M. J. Jordan	J. B. Coit
Louis Bell	Joel Stebbins	E. C. Pickering	Thomas P. Smith	C. R. Cross	A. B. Burbeck
C. A. R. Lundin	S. I. Bailey	H. T. Stetson	Otto Klotz	Louis Derr	T. C. H. Bouton

To identify in photograph, read from left to right.

FIG. 1

"THE HELIOS-AURUS"

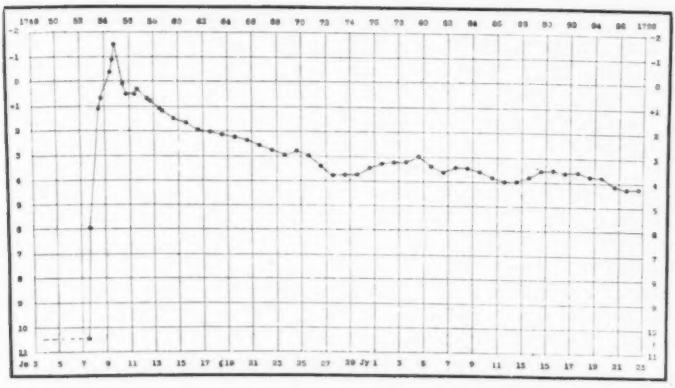

FIG. 2

PROVISIONAL LIGHT-CURVE OF NOVA AQUILÆ NO. 3

(Harvard College Observatory).

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THE TWENTY-SECOND MEETING OF THE AMERICAN ASTRONOMICAL SOCIETY.

BY RALPH E. DE LURY.

THE American Astronomical Society was invited by Director E. C. Pickering to hold its twenty-second meeting at the Harvard College Observatory, from Tuesday, August 20, to Friday, August 23. At the opening session, President Lowell, of Harvard University, and Professor Pickering, heartily welcomed the members and their friends. Very comfortable and convenient quarters were provided in Standish Hall, one of the college dormitories fronting on Charles River Parkway. The fifty or more members and guests who attended the meeting took advantage of the opportunities given them of inspecting the various parts of the observatory: the library, instrumental equipment, the storing of the photographic plates, the methods of examining and cataloging the plates, the large exhibits of astronomical photographs and transparencies, the devices for simplifying the immense labors of the institution, and the methods of observing, were of the greatest interest to all, and especially profitable to those who were not at the Harvard meeting of 1910. Great interest was had

in the visit to the Students' Astronomical Laboratory. Some members were able to find time also for a peep into the museum and some of the other buildings at the University.

On Tuesday, Wednesday and Thursday mornings, after meetings of the Council, sessions for papers were held at the observatory. Those attending enjoyed the hospitality of Professor Pickering at his residence in the observatory on Tuesday and Wednesday. A session for papers was also held at the observatory on Tuesday afternoon, followed by the taking of the group photograph (Plate XII.) and an inspection of the observatory, and in the evening by observations with the various instruments, the view of the spectrum of the nova with the large objective-prism telescope being a special feature. Professor Pickering and the members of his staff were indefatigable in making the examination of the observatory and its work interesting and complete.

By invitation of Director J. C. Duncan, an excursion was made on Wednesday afternoon to Whitin Observatory, Wellesley College. The visitors were taken by special electric car, through interesting towns and country, to Wellesley, where they were met by motor cars sent by the college to take them to see the beautiful college grounds and buildings, and also the "war gardens" and the food canning and drying operations which are worked and managed by the students. They were then taken to Tower Court, the largest of the college dormitories—a magnificent building, where they were met by the Registrar of the College, Miss Edith Tufts, representing the President, Miss Pendleton, who was unavoidably absent. Miss Whiting, former director of Whitin Observatory, gave a brief history of the building and a description of the decorations, many of which were bequeathed by Lady Huggins. The visitors then proceeded to the Library of the college, where they were shown the stacks of books, old and new, and the Lady Huggins collection of books and jewels; then to the Art Building, where they were shown a model of the new buildings which it is planned shall be built for the college within a few years. The visitors then strolled across the valley and up to the observatory, the inspection of which proved very profitable and interesting.

They were then taken by Professor and Mrs. Duncan to their residence, "Observatory House," where supper was served. In the evening a session for papers on the solar eclipse, profusely illustrated by lantern slides, was held in the observatory, after which the visitors returned to Cambridge by special car, having spent a most enjoyable day.

On Thursday afternoon, by invitation of Professor Willson and Dr. Stetson, lunch was had at the Students' Astronomical Laboratory, followed by an inspection of the old and historic books and astronomical and surveying instruments, and the modern equipment, including Dr. Stetson's thermo-electric photometer, and numerous devices for teaching. The visitors greatly appreciated Professor Willson's gift to them of copies of his book on "Laboratory Astronomy," a valuable little work containing six chapters well-filled with explanations, methods and experiments. Before the final session for papers, which was held in the large lecture room, Professor Willson and Dr. Stetson demonstrated some of the interesting devices for teaching,—Algol eclipsing, stars transitting, etc. Those attending the meeting were invited to take a cruise on the "Adventuress," a large converted schooner which had been fully equipped by a graduate of Harvard and loaned to the Astronomical Laboratory to aid, in the present crisis, in teaching navigation.

On Friday some of the members went on the cruise, and no doubt had a most delightful experience. Others accepted the invitation of President Maclaurin and Professor Cross to inspect the Massachusetts Institute of Technology. This building, occupied in 1916, is situated on the Charles River Basin. It is massively constructed, being nine stories high and extending half a mile from one end of the U around to the other. Members of the staff conducted the party of visitors through the fine library and a maze of laboratories, workshops, teaching and demonstration rooms, explaining the special features of the equipment and methods for technical instruction and investigation in chemistry, physics, geology, biology, etc., and in chemical, electrical, hydrau-

lic, mechanical, mining and sanitary engineering. This marvellous institution is at present carrying on a great deal of war work.

After the visit to the "Tech.," some of the members staying still later, were given a delightful motor drive along the beautiful parkways by Professors Pickering, Bailey and Hinkley.

A considerable number of new members were elected, the total membership of the Society being now well over 300. On Wednesday morning nominations for officers for the coming year were received, and on Thursday morning the elections resulted as follows: *President*, Edward C. Pickering; *First Vice-President*, Frank Schlesinger; *Second Vice-President*, W. W. Campbell; *Secretary*, Joel Stebbins; *Treasurer*, Annie J. Cannon; *Councillors for* 1917-19, Edwin B. Frost, S. A. Mitchell; *Councillors for* 1918-20, E. W. Brown, Otto Klotz.

At the final session the Society heartily adopted the resolutions, proposed by Dr. E. W. Brown, and seconded by Dr. Otto Klotz, expressing the appreciation and thanks of the Society to the authorities and staffs of Harvard College, Harvard Observatory, Harvard Astronomical Laboratory, Whitin Observatory, Wellesley College, and Massachusetts Institute of Technology, as well as to President Pickering, Vice-President Schlesinger, Acting-Secretaries Stebbins and Jordan and the other members of the Council of the Society, for the splendid arrangements made for holding the meeting and carrying out the sessions, and for the excellent provisions made for the entertainment and comfort of the members and their friends attending the meeting.

A record number of titles of papers was submitted, but only thirty-eight were received by Acting-Secretary Stebbins in time for printing on the program, and consequently the original plan of extending the sessions over until Friday was modified so that the meeting would end on Thursday afternoon, and other plans were made accordingly. Thirty-nine additional titles of papers were received after this; but the skilful chairmanship of President Pickering and Vice-President Schlesinger made it possible to finish the sessions on Thursday. Owing to delays in the mails, a number of the papers did not arrive in time for presentation at the meeting.

so it was unanimously decided that abstracts of these papers be printed along with the abstracts of the presented papers and reports of committees in the *Publications of the Society*. No doubt these abstracts will appear as usual in *Popular Astronomy*, and many of the papers will be published in full in various journals and the reports of observatories, so that only brief reference to them need be made here.

Two special astronomical events, the Solar Eclipse of June 8, and the arrival of the tidal flood of light from Nova Aquilae, No. 3, discovered on the same date, provided material for thirty per cent. of the papers, ten papers on the eclipse and thirteen on the nova. There were ten papers on the sun and satellites, twelve on binaries, orbits and variables, five on clusters and nebulae, nine on stars in general, eight on observatories, equipment and mechanical devices, and ten on miscellaneous topics, making in all seventy-seven papers. The papers will be mentioned briefly under these headings.

The Solar Eclipse of June 8.—After travelling long distances to carefully selected sites, and making extensive and arduous preparations for observations during the few seconds of precious gloom of total eclipse, and then to be enshrouded in the apparently hopeless gloom from clouded and hazy skies, was the experience of most of the expeditions located along the path from Washington to Florida. However, for many, the clouds parted in miraculous fashion just in time to allow almost perfect and complete observations to be made. As a result, many excellent photographs and lantern slides were shown at the meeting. The papers were: W. F. Rigge, Eclipse as observed in Omaha; Jacob Kunz and Joel Stebbins, Photometric Results; J. A. Parkhurst, Spectrum of Corona; E. B. Frost, Usefulness of a "Movie" Camera for Photographing Phenomena of Solar Eclipses; W. S. Adams and C. F. St. John, Green Coronal Line; V. M. Slipher, Spectroscopic Results, and C. O. Lampland and E. C. Slipher, Photographic Results (Lowell expedition); J. A. Miller, Solar Eclipse; E. Pettit and Hannah B. Steele, Washburn College Expedition to Matheson,

Colorado; George E. Hale, Mount Wilson Eclipse Photographs. Professor John A. Miller presented copies of a large photograph taken at Brandon, Colorado, by the Sproul expedition from Swarthmore College, with the nine-inch lens of sixty-two and a half feet focal length. Various lantern slides showed an interesting prominence, which the Mount Wilson party called the "mosquito prominence," and which to others suggested some prehistoric monster, and gave "scientific" justification to the Chinese custom of frightening away the dragon from the sun at such times (Plate XIII., Fig. 1). Professor Frost's "movies" of the flash spectrum were very successful, some hundreds of photographs being taken at the rate of sixteen to the second. By using an iron-arc comparison spectrum, Adams and St. John obtained from a spectrogram of the coronal line from the east equatorial limb, the value of its wave-length, λ 5303.157 (International units), or λ 5303.239 in Rowland's system, allowing a correction corresponding to 2.00 km. sec. for the rate of rotation. Unfortunately they were unable to get the spectrum of the west limb on account of cloudiness, so that the rate of rotation of the corona could not be definitely determined. Kunz and Stebbins were able to measure the strength of the corona by means of the photoelectric cell. They found intensities up to about one-tenth the strength of moonlight, and they suggest that its presence might be detectable in daylight through clear skies. The Lowell expedition secured some fine photographs and spectrograms. The Washburn College expedition obtained excellent photographs, but the attempts to photograph the corona before and after totality showed not sufficient contrast with the sky light.

The Sun and Satellites.—The papers which come under this heading were: Margaret Harwood, "Variability of Eros, 1900-1901." A maximum brightness of mag. 11.0 or 11.1 was found, and a period of .2196 days indicated, with irregularities in range, which varies from six to eight tenths mag. (Methods of analyzing the irregular variations were discussed by E. W. Brown and Louis Bell.). Susan Raymond, "Variability of Antigone (129)." W. F.

Meggers, "Solar and Terrestrial Absorption in the Sun's Spectrum from 6400A to 9400A." Photographs were made on plates bathed in dicyanin, and the solar and terrestrial lines distinguished on limb spectra exhibiting the rotation effect. The solar triplet, λλ7771.9, 7774.1 and 7775.4, is also obtained in arc spectra in air and ascribed to oxygen. C. G. Abbot, "The Smithsonian 'Solar Constant' Expedition to Calama, Chile." C. E. St. John and Louise Ware, "Notes on Solar Rotation." The conclusion is reached that sun's rate of rotation does not vary. Asaph Hall, "Account of Some of the Series of Satellite Observations made with the 26-inch Equatorial" (Naval Observatory). R. E. De Lury, "Simultaneous Variations in Solar Radiation and Spectroscopic Determinations of Solar Rotation"; "Spectroscopic Measurements of the Sun's Rotation at its Equatorial Limbs and at Points midway between them and the Centre of its Disc"; "The Nature of a Supposed Cyclic Variation in the Solar Rotation"; and, "A Possible Relationship between Numbers of Meteors and Quantities of Nitrogen Compounds in Falling Rain and Snow."

Nova Aquilae, No. 3.—The papers on the nova, presented together at the first session, were: W. E. Harper, "Spectrum and Velocity"; Leon Campbell, "Light Curve"; Annie J. Cannon, "Spectrum"; R. M. Stewart, "Position"; "Alice H. Farnsworth, "Color Index"; E. B. Frost, and J. A. Parkhurst, "Spectrum, June 8, 9, 10"; J. S. Plaskett, "Spectrum"; R. M. Motherwell, "Photometric Magnitudes"; R. Trümpler, "Position and Proper Motion." The following three papers were not received in time: C. D. Perrine, "Early Spectrum"; V. M. Slipher, "Spectrum"; E. E. Barnard, "Magnitude and Light Curve." Henrietta Leavitt had a paper on "The Mean Light Curve of Six Novae," which included Nova Aquilae, No. 3. According to the Harvard College Observatory *Circular*, No. 208, which Professor Pickering distributed to those present, M. Luizet (in Lyons) was the first to report the Nova, June 8, 8:40, G.M.T., while it was still under the horizon for America, and Vincent Francis was the first of many Americans to discover it, 13:00, G.M.T., on the same date.

The Harvard plates show that up to June 3 the magnitude of the nova was about 10.5; June 7, mag. 6; June 8, mag. 0.8; and on June 10 the maximum was reached at about -1.5 magnitude. This is about 60,000 times as bright as at magnitude 10.5. The Light Curve up to July 23, compiled by Leon Campbell from photometric observations and 523 visual observations from 71 persons, is given in this circular and reproduced here (Plate XIII., Fig. 2), by kind permission of Professor Pickering. Although many of the observers were inexperienced, the observations show an average deviation of ± 0.14 magnitude, including the large deviations made when the star was very bright and there were no suitable comparison stars. The Light Curve compiled by W. E. Harper from the visual observations of five persons in Ottawa and the neighborhood (who used the map in H.B., 661), showed an average of about 0.1 magnitude below Campbell's curve. Motherwell's photometric curve (after June 17) was considerably lower than the visual curve. He explains this as due to the richness of $H\alpha$ to which the plates were not sensitive. The position determined by Stewart for the nova is, R.A., 18h. 43m. 48.39s.; Decl., 0°28′ 20.4″, for 1900.0 (Boss system). Trümpler's values agree very closely with these. The papers on the spectrum of the nova agreed in revealing the remarkable changes which took place in the early days of the variations. The measurements of the displacements of the lines by Harper and by Plaskett agreed closely.

Binaries, Orbits and Variables.—The papers which may be classed under this heading were: W. E. Harper, "Orbits of Spectroscopic Binaries, Boss 5173 and 19 Lyncis"; J. B. Cannon, "Orbit of Spectroscopic Binary, Boss 1275"; R. G. Aitken, "Orbit of Sirius"; and, "The Spectral Classification of 3,919 Visual Binary Stars"; R. M. Motherwell, "Light Variations of 12 Lacertae"; W. S. Adams and A. H. Joy, "Spectroscopic Observations of *W* Ursae Majoris"; F. Henroteau, "Note on the Spectroscopic Binary, 55 Ursae Majoris"; F. C. Jordan, "Notes on the Short Period Variables XX Cygni and U Pegasi"; C. O. Lampland, "Variable Stars in the Trifid Nebula (N.G.C. 6514) and the

Lagoon Nebula (N.G.C. 6523)"; H. N. Russell, "Orbit of σ Ursae Majoris"; R. F. Sanford, "The Orbit of the Spectroscopic Binary *P* Velorum."

Clusters and Nebulae.—The following five papers dealt with these topics: S. I. Bailey, "Note on the Magnitudes of the Stars in Messier 15"; V. M. Slipher, "The Spectra of Two Variable Nebulae: A New Type of Nebular Spectrum"; C. O. Lampland, "Photographic Observations of the Variable Nebula, N.G.C. 2261"; E. E. Barnard, "Small Dark Objects in the Milky Way"; John C. Duncan, "Photographs of the Andromeda Nebula and Messier 22" with the 60-inch Mount Wilson Telescope.

Stars in General.—The papers dealing with general stellar problems were: E. C. Pickering, "Relation of the Proper Motions to Spectrum" (in which statistical relationships between certain pairs of six functions such as proper motion, type, numbers, parallax, etc., were discussed); Benjamin Boss, three papers on, "Systematic Corrections to and Weights of Stellar Parallaxes"; "Stellar Luminosities," and "Real Stellar Motions"; Margueretta Palmer, "The Yale Index to Star Catalogues"; J. J. Crane, "Reduction of Schönfeld's Early Observations." The following three papers did not arrive in time from Cordoba: C. D. Perrine, "Announcement concerning the Formation of a new Catalogue of Fundamental Star Positions"; and, "Changes in the Spectra of Early Type Stars, Showing Hydrogen Emissions"; M. L. Zimmer, "Preliminary Note on an Annual Term in the Right Ascensions."

Observatories, Instruments and Mechanical Devices.—E. C. Phillips, "A New Method of Determining the Instrumental Correction to be applied to Transit and Meridian Circle Observations" (in which a simple mechanical contrivance for speedy and accurate computations is described); E. S. King, "New Methods of Determining the Color of a Star" (By placing a pair of filters, say red and blue, in front of an objective and photographing out-of-focus images of stars, the discs of the images are produced half by red

light and half by blue light, thus making it possible to measure the relative intensities of the two colors in the star; in a similar manner the Pleiades were photographed with an H on each star disc, producing a decidedly weird effect.); Luis Rodés, "A Differential Gravimeter and its Applications"; R. K. Young, "Probable Error of Radial Velocities," determined with the One Prism Spectroscope of the Dominion Astrophysical Observatory; J. S. Plaskett, "The 72-inch Reflecting Telescope"; David Todd, "The Construction of High-Level Laboratories for Scientific Research"; Asaph Hall, "Brief Description of the 26-inch Equatorial Instrument of the Naval Observatory, and Accessories"; A. E. Douglass, "Steward Observatory" (recently established at Tucson, Arizona).

Miscellaneous Topics.—F. W. Very contributed five thoughtful papers on: "The Luminiferous Ether"; "What is the Bearing of the Hypothesis of a Gravitational Limit on the 'Relativity' Discussion?"; "The Wasting of Stellar Substance"; "Galactic and Atomic Vortices"; and on "Nipher's 'Gravitational' Experiment." Sebastian Albrecht's paper on "Personality in the Estimation of Tenths" revealed a tendency of some observers to a preference for certain tenths, and a constant reference to accurate settings at the various tenths is suggested as a corrective. H. T. Stetson had two papers on "War-Time Instruction at the Harvard Astronomical Laboratory," and "Preliminary Note on the Uniformity of Film Sensitivity of Photographic Plates from Measures with a Thermo-Electric Photometer." In a paper by W. A. Conrad on "A Short Method of Mean Place Reduction with Natural Numbers," it was shown that a "Millionaire" computing machine yielded more rapid and accurate reductions than did logarithms. A. E. Douglass had a note on "Atmospheric Haze, causing Remarkable Twilight Effects."

Reports from Committees on Variable Stars, Parallaxes, Photographic Astrometry, etc., were presented and adopted. The report on the time of commencing the astronomical and civil days created much discussion. Finally the Society adopted resolutions favoring the commencement of both the astronomical and civil

days at midnight and numbering the hours from 0 to 24, from January 1, 1925. This resolution is in harmony with decision of the French Hydrographic Department, with the sentiments of prominent members of the British Admiralty, and with the resolutions of the Royal Astronomical Society. It is hoped that the Royal Astronomical Society of Canada, after having adopted similar resolutions*, will point out to the Dominion Government the advisability of taking definite action thereon at an early date.

The meeting was very successful. All of the papers and reports were interesting. It is regretted that details of the many important papers cannot be given here, but, as pointed out before, such details will appear in various publications in the near future, and the reader will find much of interest and value by referring to them.

DOMINION ASTRONOMICAL OBSERVATORY,
Ottawa, Canada,
September, 1918.

*(See this *Journal*, vol. xi., p. 362, 1917.)

THE BADGE

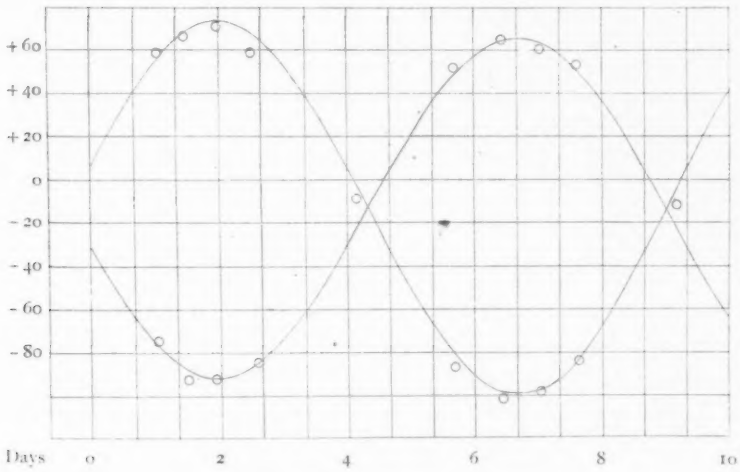
THE ORBITS OF THE SPECTROSCOPIC COMPONENTS OF BOSS 5173

By W. E. Harper.

THIS star, right ascension $20^h\ 03^m$, declination + 26° 37′, magnitude 5·5, type *A*, was announced a spectroscopic binary by Adams in June, 1915, from measures of three plates. He noted that the hydrogen lines showed great variations in width and intensity and suspected that both spectra were present.

The star has been one over which the writer has expended a great deal of time, due in part, and possibly wholly, to the uncertainty of the measures. The period and general form of the velocity curves were readily obtained in the autumn of 1916 but when it came to a rigid determination of the elements there appeared to be a difficulty. In these cases where both spectra are recorded two curves are obtained for which the period, eccentricity, velocity of the system, and time of periastron passage must be identical and the longitudes of periastron must differ by 180 degrees. With the exception of the velocity of the system all the other elements agreed but in the case of this element there was a difference of some 10 or 15 km. as derived from the two curves. Several solutions were put through without removing the discrepancy and additional plates were then secured in the two following seasons. 62 out of the 75 observations secured have been utilized in the final solution, the remaining plates being uncertain by reason of the overlapping of the spectra. The later observations minimize the discrepancy to some extent but cannot be said to remove it altogether. However, when one reviews the plates and sees what few ill-defined lines the velocities are based upon and further considers that for about one-half the period the lines are partially superposed, making measurement impossible, it would appear that the best of agreement can

not be hoped for. Consequently since different values for the velocity of the system for the two components would be physically impossible it seems better to go on the assumption of a common velocity even though better agreement can be secured when different values for each are used.



VELOCITY CURVES OF BOSS 5173

The probable error of a plate is for the primary ± 4·8 km. per sec. and for the secondary ± 6·9 km. per sec. All plates were measured twice with a considerable interval elapsing between measures.

The final elements are :

$$P = 9{\cdot}316 \text{ days}$$
$$e = {\cdot}012$$
$$\omega = 103°{\cdot}15$$
$$\omega_1 = 283°{\cdot}15$$
$$K = 78{\cdot}49 \text{ km.}$$

$K_1 = 86{\cdot}31$ km.
$\gamma = -13{\cdot}04$ km.
$T =$ J.D. 2,420,304·628
$a \sin i = 10{,}054{,}000$ km.
$a_1 \sin i = 11{,}055{,}000$ km.
$m \sin^3 i = 2{\cdot}27 \times$ sun.
$m_1 \sin^3 i = 2{\cdot}06 \times$ sun.

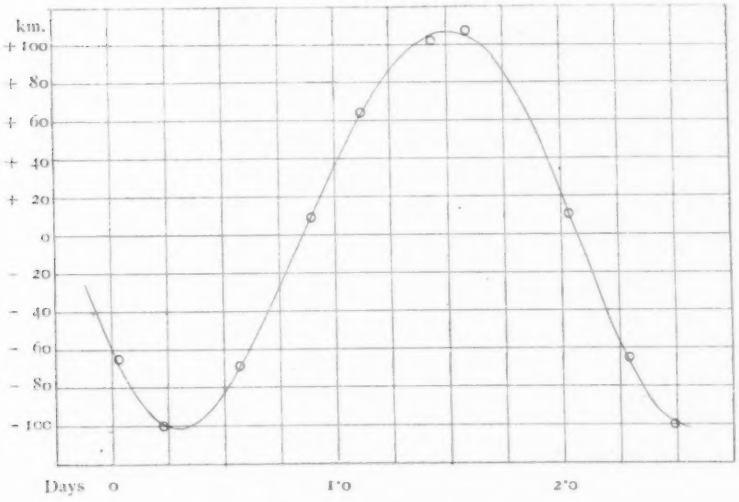
DOMINION OBSERVATORY,
OTTAWA, CANADA,
March, 1918

THE ORBIT OF THE SPECTROSCOPIC BINARY 19 LYNCIS

By W. E. Harper

THE star 19 Lyncis, right ascension $7^h\ 15^m$, declination + 55° 28′, magnitude 5·6, type *B*8, was announced a spectroscopic binary by Adams, in 1911, from three plates whose appearance indicated that two spectra were present.

Thirty-seven plates have been secured here in the years 1915, 1916, 1917 and 1918. Values of the period differing slightly from each other were possible from the first two season's plates but the last two seasons tied the period down to 2·25960 days. The remaining elements are:—



RADIAL VELOCITY CURVE OF 19 LYNCIS

$$e = \cdot 076$$
$$\omega = 126^\circ \cdot 11$$
$$\gamma = + 7 \cdot 37 \text{ km.}$$
$$K = 104 \cdot 43 \text{ km.}$$
$$T = \text{J.D. } 2,419,031 \cdot 632$$
$$a \sin i = 3,235,400 \text{ km.}$$
$$\frac{m_1^3 \sin^3 i}{(m + m_1)^2} = 0 \cdot 26 \times \text{sun.}$$

While the lines λ4549, λ4481 and λ3933 are occasionally measured, in addition to the hydrogen lines, yet none are of good quality and the probable error of a plate is ± 6·9 km. per sec. The lines of the secondary are too weak and the measurements too uncertain to obtain the ratio of the masses of the two bodies.

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July, 1918.

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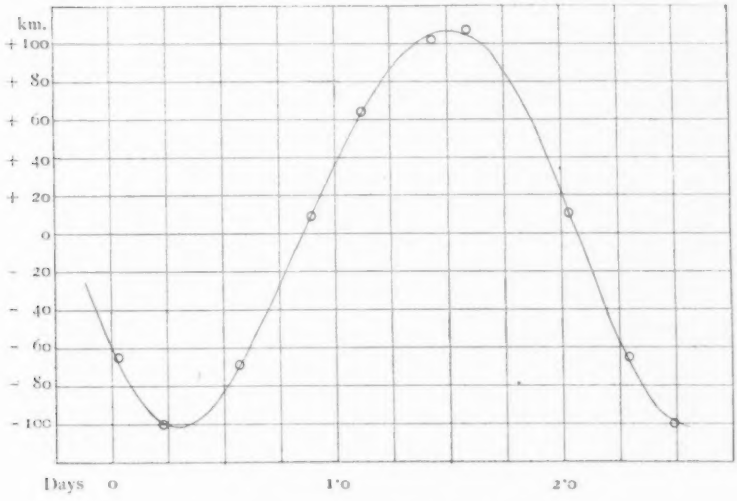

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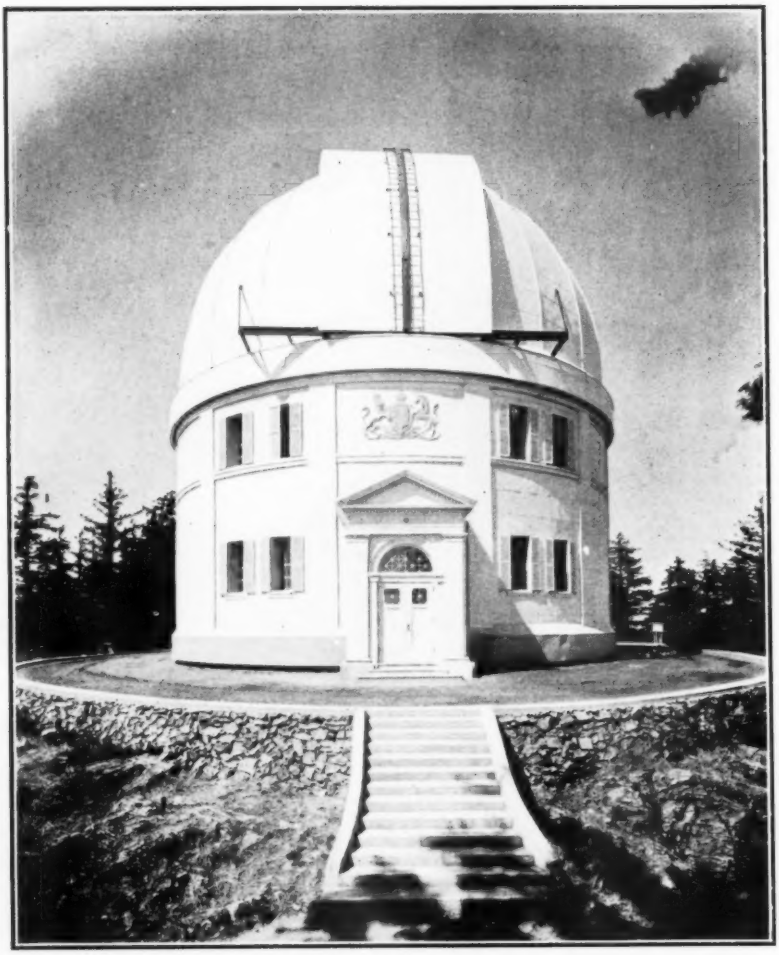
$$a \sin i = 3,235,400 \text{ km.}$$
$$\frac{m_1^3 \sin^3 i}{(m + m_1)^2} = 0 \cdot 26 \times \text{sun.}$$

While the lines λ4549, λ4481 and λ3933 are occasionally measured, in addition to the hydrogen lines, yet none are of good quality and the probable error of a plate is ± 6·9 km. per sec. The lines of the secondary are too weak and the measurements too uncertain to obtain the ratio of the masses of the two bodies.

DOMINION OBSERVATORY,
OTTAWA, CANADA.
July, 1918.

PLATE XIV.



THE DOMINION ASTROPHYSICAL OBSERVATORY, VICTORIA, B.C.

THE 72-INCH REFLECTING TELESCOPE

By J. S. Plaskett

THIS instrument, which at different stages of projection, design and construction has already been described in these pages, has been finally completed by the installation of the optical parts and is now in regular successful operation.

Its completion marks an epoch in the history of astronomical research in Canada, and when the Observatory is fully staffed, the results obtained with this splendid instrument will be of great value in their bearing on the astronomical problem of prime importance, the structure and constitution of the universe.

For a complete account of the various stages of the work, the reader can be referred to back numbers of this Journal. In Vol. VII., p. 216, the late Dr. W. F. King gave an account of the authorization of the project and the specifications upon which tenders were invited. In the same volume, p. 448, the present writer gives the history of the undertaking, with a preliminary description of the design of mounting proposed. An account of the investigations carried out by Mr. Harper and supplemented by the writer, with the reasons which led to the selection of what is now Observatory Hill, near Victoria, for the site of the telescope, and with the progress made in the preliminary work, is given in Vol. VIII., p. 180. In Vol. X., p. 275, is given a full description of the mounting of the telescope, which at the time of writing was completed, but not yet erected.

It is proposed in the present paper to give a short account of the erection of dome and telescope, with a description of the essential features of the former; but its main object will be to complete the description of the Observatory by an account of the grinding and polishing of the mirror, its testing and installation, and of the performance of the completed equipment.

The dome, which, in a large reflecting telescope, is an important part of the equipment, was designed and constructed by the Warner & Swasey Co., the builders of the telescope mounting. It was shipped from Cleveland early in March, 1916, arriving in Victoria about the end of the month, and was erected by July 1st. The double sheet metal covering was not, however, completed and the operating mechanism adjusted and put into working order until October.

The dome is 66 feet in outside diameter, revolving on roller bearing wheels on a circular rail, and driven by an electric motor operated from one of the telescope switchboards at the rate of one revolution in 6 minutes. It has large double shutters also operated by electric motor, giving a clear opening of 15 feet, which extends 6 feet beyond the zenith. To prevent the wind shaking the tube of the telescope, two electrically operated canvas wind screens are provided, moving up from the bottom and down from the top of the shutter opening, thus enabling the length of the opening to be limited to the diameter of the tube. However, one of the most important features of the dome, a considerable advance over previous practice, and for which the Observatory is indebted to the genius of Mr. Burrell, Works Manager of the Warner & Swasey Co., is the observing platform, which travels on curved rails on the main ribs of the dome, is maintained horizontal by an ingenious differential hoisting arrangement, and can be readily brought by electric motor to any desired height so as to allow convenient access to the upper end of the tube in any position, when the telescope is being used at the principal or Newtonian focus. This platform, which is about 20 feet long and 4 feet wide, is provided with two wings, one at each end, projecting into the dome and each movable by hand wheel to any part of the length of the platform. These extend out from the platform about 6 feet, and as they are of a circular form on the inner sides, enable the telescope tube to be reached, over more than half its circumference, in any position it may be used.

Both dome and building have a double sheet metal covering ingeniously united by weather guarding at the junction of the two,

so as to allow circulation of air through openings at the bottom of the building up between the inner and outer walls of building and dome and out through louvres at the top. This is for the purpose of preventing overheating of the interior during the day time; while the construction being entirely of metal, enables it to quickly take up the night temperatures and prevent convection or radiation from interfering with the definition. This, combined with the very considerable masses of metal within the coverings, reduces appreciably the diurnal range of temperature within the dome, while at the same time, when once opened, the circulation through the large opening allows temperature inside and out to be rapidly equalized.

As mentioned in a previous article, the mounting of the telescope was completely erected and fitted at Cleveland in March, 1916. A reception and private view of the mounting, to which representatives of the department, eminent astronomers and other people interested were invited, was held on May 25th, after which the mounting was taken down and shipped to Victoria. It arrived about the middle of August, and arrangements were made with Messrs. Skillings and Hamon, who were accustomed to handling heavy material, to haul the parts to the Observatory and to provide the tackle and labor for hoisting to the observing floor, 21 feet above the ground floor, and for placing in position. Messrs. Warner and Swasey sent out their superintendent, Mr. Decker, to look after the erection. He arrived on September 5th, but in the meantime everything had been hauled from Victoria and hoisted to the observing floor ready for erection.

A convenient and safe hoisting tackle had been provided by Messrs. Skillings and Hamon, consisting of a horse-driven capstan placed outside the building, with a three-quarter inch wire cable leading to heavy sheaves fastened to the main ribs of the dome, which were amply strong to support the heaviest parts of the mounting. The deflection observed by a transit, when the polar axis, weight 9½ tons, was lifted, was not greater than one-sixteenth inch. By means of this tackle, the main bearings were placed in position before Mr. Decker arrived, a steel wire stretched

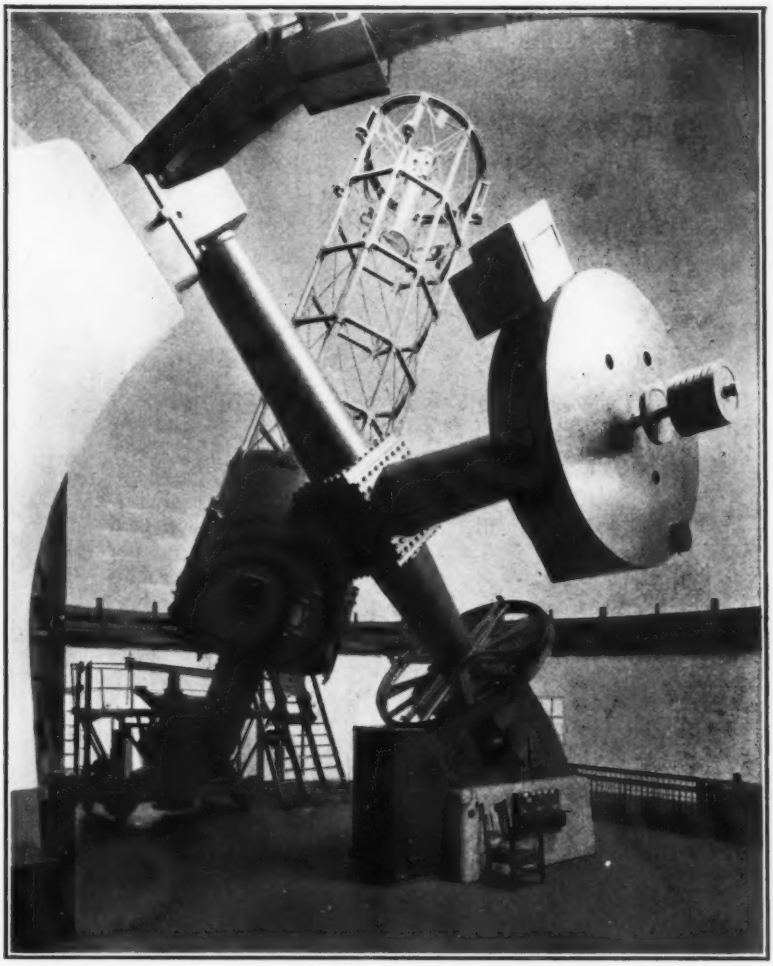
between them and the north bearing adjusted in altitude and azimuth until the wire, by a transit instrument, was as nearly parallel as could be determined, to the earth's axis. Later observations when the telescope was erected showed that it only required moving about 0.03 inch in azimuth and 0.02 inch in altitude, which, in the 20 ft. length of the polar axis, is equivalent to 17 and 25 seconds of arc respectively. It was important to have this preliminary adjustment as close as possible, as otherwise readjustment of the clock and worm drive mechanism would be required after erection, a troublesome process.

After Mr. Decker arrived, the erection went forward rapidly and smoothly, the most difficult and delicate part being the placing of the polar axis. This had to be hoisted at the exact angle with the worm and spur gears, circles and clamping mechanism attached, the total weight being about 14 tons, and placed exactly in its bearings. This was successfully accomplished in three or four days after erection started. All the heavy parts were in place in less than three weeks and the telescope completed, with the exception of the electrical wiring and connections, which required some three weeks longer. That the whole erection of this mammoth instrument was completed without a hitch and the mounting ready for operation in six weeks, is a tribute to the attention paid in the design to this feature, and to the care with which everything was fitted in Cleveland.

After Mr. Decker left, about October 15th, the adjustment of the axis was tested by the long focus finder of 7 inches aperture, 30 feet focus, attached centrally in the tube by temporary adapters, and I returned to Ottawa, Mr. T. T. Hutchison, who was appointed Engineer in Charge, being left to look after the equipment in the interim. A further test on my return in July, 1917, showed a slight change, due possibly to settling of the concrete piers; but the mounting and dome were ready for operation in October, 1916, and the only thing lacking was the mirror and other optical parts.

On the second trial, a disk of glass 73½ inches in diameter, about 13 inches thick, with a central hole some 6 inches in diameter, and weighing nearly 5,000 lbs., was successfully cast and

PLATE XV.



THE 72-INCH REFLECTOR, WITH SPECTROSCOPE ATTACHED

Journal of the Royal Astronomical Society of Canada, 1918

annealed at the works of the St. Gobain Glass Co. in Charleroi, Belgium. It was completed in July, 1914, and fortunately the Brashear Co. asked that it be shipped at once and not held until the disk for the testing flat, 55 inches in diameter, was completed. As it was, it left Antwerp only about a week before war was declared, and if it had been held, would probably have been destroyed and the telescope indefinitely delayed, as the glass factory at Charleroi is now in ruins.

It arrived in Pittsburgh in August, 1914, and grinding operations were at once begun. Three or four months were required in the rough grinding by which the front and back were made parallel, the back approximately flat and, as the focal length was to be 30 feet, the front a section of a sphere of 60 feet radius. This meant that the centre was about nine-tenths inch thinner than the edge. At the same time, the periphery was ground circular and the central hole made true and about 10 inches in diameter. The glass was reduced to a diameter of 73 inches and a thickness of the edge of 12 inches, some 600 lbs. of glass being removed, the finished weight of the mirror alone being 4,340 lbs. The front surface was then fine ground to the true radius and polished and the back polished approximately flat. The mirror now, after six months' work, looked exactly the same as when finished; but, of course, the working surface, though probably correct to less than one-thousandth of an inch, was nowhere near an optical surface and the difficult and delicate task of the "figuring," the polishing required to bring the surface to the true curve, remained.

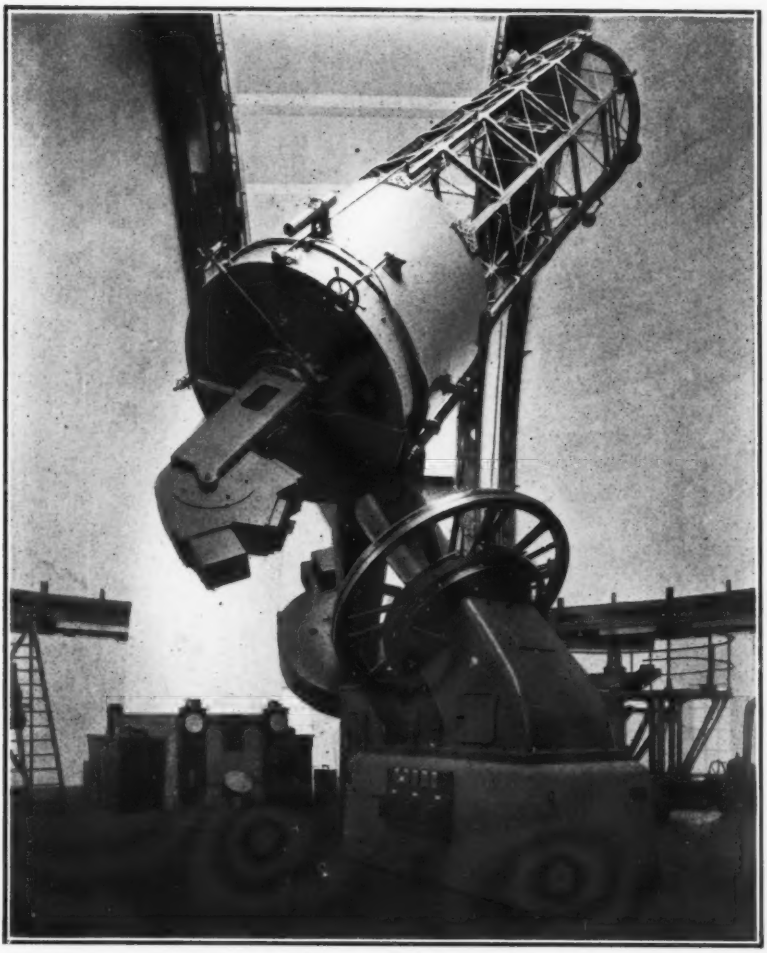
It was at first proposed to test the surface of the 72 inch by the aid of an auxiliary flat mirror 55 inches in diameter, but the impossibility of getting the disk for this mirror from Europe and the failure of two or three efforts to obtain it in America, made it necessary to change the plan of testing the surface. Consequently, very little was done on the 72 inch for a year, until it was found impossible to obtain the flat, when it was decided to test the paraboloid of revolution by measuring the radius of curvature of different zones and figuring until the measured radii agreed with the computed. The surface of a mirror which will bring all

the light from a star to a focus is not spherical, but is one formed by the revolution of a parabola along its axis. This curve is such that it is slightly flatter near the edge than the centre, the distance to the centre of curvature of the edge of the 72-inch mirror being nine-tenths inch longer than the distance to the centre of curvature of the middle. This distance, nine-tenths inch, is the same as the depth of the curve at the middle, the difference between the thickness of centre and edge. Hence as these radii of curvature can be accurately measured optically, it forms a means of determining when the surface is truly parabolic. The general smoothness and regularity of the curve can be determined by the aid of a flat surface smaller than 55 inches, and as the Brashear Co. already had a very fine plane 33 inches in diameter, the quality of the surface could be determined with the same accuracy, although not quite so quickly and easily, as with a larger plane.

Very considerable difficulties were encountered in the figuring of this large surface, due chiefly to temperature changes caused by the polishing and to the presence of the central 10-inch opening, which greatly interfered with the regularity of action of the large, full size polishers employed in much of the work. The material of which the disk is made is a beautiful example of the glass maker's art, as it is apparently perfectly homogeneous and free from appreciable defects, there only being a few small bubbles at one particular part of the interior of the glass, which can do no possible harm. It was found inadvisable to polish more than half an hour or so at a time, when the glass had to be placed in the testing tube and allowed to stand at least 12 hours before the tests, to determine the effect of the polishing, could be depended on to give the true reading.

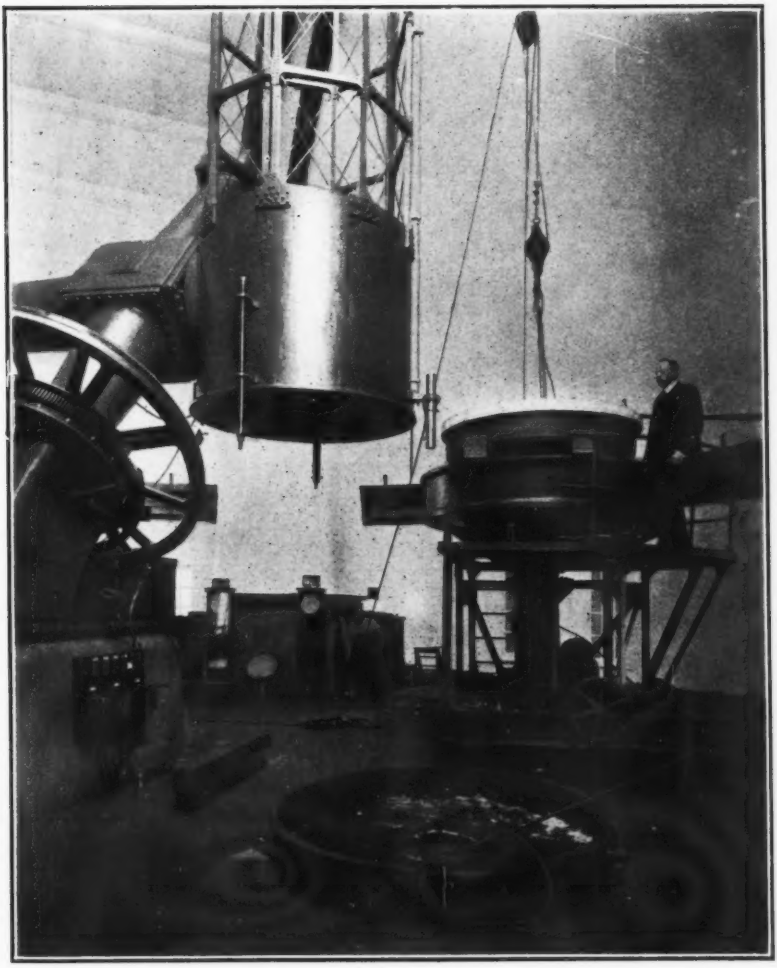
The amount taken off any one part of the mirror by half an hour's polishing was only of the order of one or two millionths of an inch, and to get the curve to within a quarter wave length, one two-hundred-thousandth of an inch, of the theoretical form, was an exceedingly difficult and tedious process. The figuring was practically begun during the summer of 1916 and was continued with little intermission for nearly two years, until April, 1918,

PLATE XVI.



ANOTHER VIEW OF THE TELESCOPE WITH SPECTROSCOPE ATTACHED

PLATE XVII.



MIRROR HOISTED ON SILVERING CAR

until it was finished. Twice during this interval the surface was nearly right, but scratches appeared or one part of it was polished too deep, necessitating starting again several stages back.

I was finally summoned to Pittsburgh towards the end of March, 1918, and found the outer part of the mirror practically perfect, but towards the centre it required slightly more polishing. It was left high here purposely, technically called "undercorrected," in the belief that the normal conditions of temperature under which the mirror is used would tend to lower this region and that it would make a better working surface with this undercorrection left in. However, tests under varying conditions of temperature always indicated that any change rather tended to increase than decrease this undercorrection, and at my request, some more work was done around the centre, and in three or four days this undercorrection was removed and the whole surface passed the rigorous tests applied.

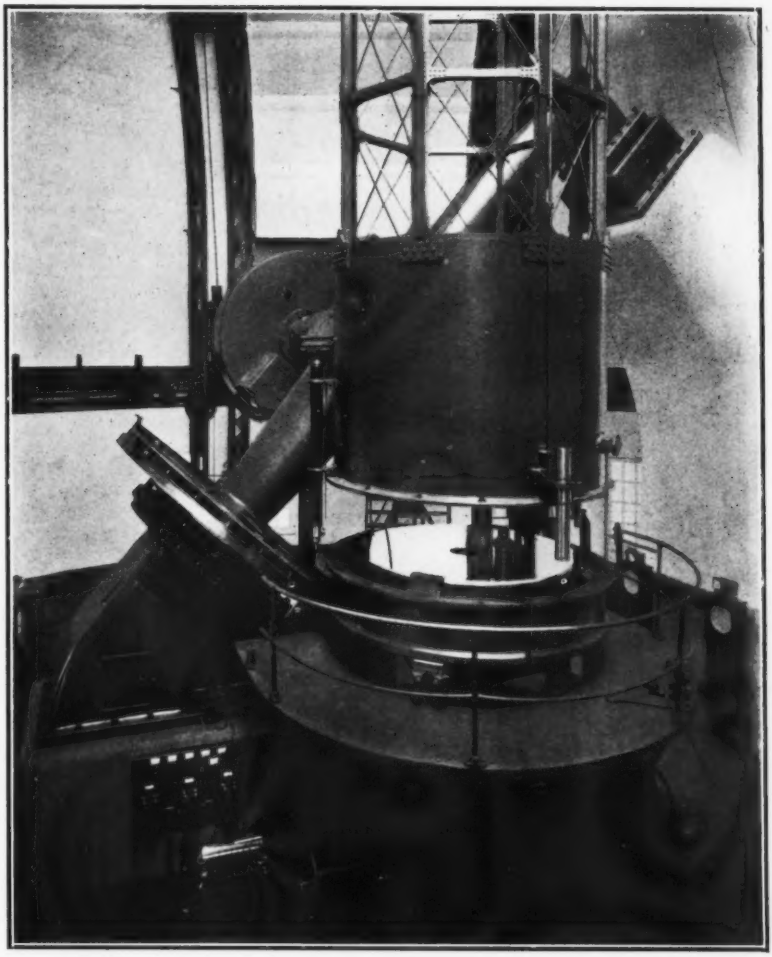
These tests consisted first of measurements of the radius of curvature of eight different zones of the surface. These zones were of radii 35, 31, 27, 23, 19, 15, 11, 7 inches, and determined the form of the curve at these points. That the curve was smooth in intermediate positions and that the change of curvature progressed regularly, was determined by examining the whole surface at the centre of curvature with the knife edge test or at the focus by means of the auxiliary plane. Any irregularity or lack of continuity of the surface could be at once detected by these methods and the form of the whole surface obtained. Numerous measures were made at the centre of curvature and they agreed in showing that the deviations were exceedingly small. They were of such magnitude that the greatest deviation along the axis from the mean focus of the image of a star for any zone measured was only one one-hundredth of an inch, one quarter of a millimetre. This is equivalent to saying that the star image would thereby be increased in diameter over the theoretical amount by only about the one-thousandth of an inch, an amount quite inappreciable in comparison with the enlargement caused by imperfect seeing conditions in practice.

After the surface was silvered, it was further tested by the Hartmann method of extra-focal exposures and the radii of curvature of zones every two inches across the surface thereby determined. These measures confirmed the previous ones, and both united in showing, when translated into deviation of the curve from theoretical perfection, a maximum departure of only about one-eighth of a wave length, double the accuracy required by the specifications.

I was naturally very much delighted at having such a splendid surface on the mirror, and the Jno. A. Brashear Co. are to be congratulated not only on the perfection of the optical surface, but on the mechanical finish, as there is not a single scratch visible over the whole of this large surface. I wish to express here my gratitude to Dr. Brashear, the chairman; Mr. Jas. B. McDowell, the secretary and manager, and Mr. Fred Hagemann, the optician, who put the finishing touches upon the surface, the three men most concerned, for their persistent and successful efforts, under most trying and adverse conditions, to make this glass one of the best in existence. The finishing of a large surface such as this entails a tremendous nervous strain on all engaged on it even under normal conditions, and when to this is added the mental worry occasioned by their efforts to supply optical parts for military instruments in quantities many times greater than they had hitherto turned out, and in the face of tremendous difficulties in the way of obtaining suitable optical glass for these parts, I consider myself extremely fortunate and the cause of astronomy to be congratulated, that the mirror was finished at all, let alone with so satisfactory a surface.

Although the central hole is a great advantage in the operation of the telescope, doing away with an additional reflection, and making the position and use of the spectrograph much more convenient and mechanically suitable, yet the difficulties of figuring were thereby more than doubled and it would have saved considerable time and trouble if a plate of glass had been temporarily cemented in the hole before the fine grinding and polishing, so as

PLATE XVIII.



MIRROR AND CELL READY TO ATTACH TO TELESCOPE

to have one complete unbroken surface for the polishing operations.

After the 72-inch mirror was finished, the Cassegrain secondary mirror, 20 inches in diameter, convex on the front surface, had to be figured in connection with large mirror and the plane. This, though by no means an easy matter, only occupied about a week and then the optical parts were packed and shipped to Victoria.

The 72-inch mirror was left in the strong cast iron cell it had been ground and polished in and a strong wooden cover was bolted on the open top of this cell, thereby completely enclosing the mirror. This was then packed in a large wooden box with excelsior, and it and the other optical parts were shipped by express in a through car to Victoria, so that no trans-shipment at any point was necessary. It went through without delay, arriving in Victoria six days after leaving Pittsburgh, and was hauled out to the Observatory the second day following without accident or hitch of any kind.

A very satisfactory and safe way of handling the mirror, placing it in its cell and installing on the telescope had been devised. No risk of accident could be taken and consequently great care in the selection of the hoisting apparatus, and in the hitches and fastenings required was exercised. The wooden box in which the mirror was shipped was about 7 feet 6 inches square and 2 feet deep, and in order to get inside the entrance door, was turned up on edge and run in on rollers. The opening in the observing floor through which it had to be lifted, was about 7 feet 6 inches by 3 feet 6 inches and would not allow the outer box to pass through. The Brashear Co. had provided a strong eyebolt screwing into one of the trunnions of the iron cell, and consequently the mirror, encased in its iron cell with wooden cover, was lifted the 21 feet to the observing floor on edge and then gently let down, face up, on blocking.

In the meantime the mirror cell of the telescope had been removed from the tube and the wooden box filled with boiler punchings of the same weight as the mirror, which had been used

to balance the telescope similarly to its final condition, was removed. In order to provide for the resilvering of the mirror, a special mechanism had been devised and constructed by the Warner & Swasey Co. which is called the "silvering car." It consists of a substantial structural steel frame mounted on flanged wheels which roll on tracks in the steel floor east from the centre to the wall of the dome. On this frame is mounted vertically a massive screw plunger operated by electric motor or handwheel over a range of 30 inches, and on the top of this plunger a triangular rocker, on which the mirror cell rests, is supported at the centre of gravity of mirror, cell, and rocker. Hence to remove the cell and mirror from the telescope, the tube is turned to the vertical position on the east side of the axis, the silvering car rolled under it, the rocker screwed up into contact with the bottom of the cell and the bolts connecting cell and centre section of the tube removed. Before cell and mirror, which weigh about six tons, can be removed, a special counter-weighted vertical truss is run up through the observing floor. This is necessary to support the outer end of the declination axis and to prevent rotation around the polar axis, while the upper end of the tube is fastened to rings attached to the dome to prevent rotation on the declination axis. A good view of the silvering car and of the methods used in handling the mirror is given by the three photographs showing the installation of the mirror. The vertical truss supporting the outer end of the declination axis can be seen in Figs. 2 and 3, and when not used is pushed down in its guides below the floor and a cap placed in the opening.

When these supports are in place and the bolts removed, the motor runs down the cell quickly and the car is rolled eastward from under the tube. A band of paraffined paper can be tied around the outer edge, a plug placed in the central hole and the solutions poured on. The mirror can be easily rocked around its centre of gravity on a steel ball pivot from the working platform on which the writer is standing in Fig. 1, about 6 feet from the floor. This provides an expeditious, convenient and perfectly safe way of handling the mirror during the silvering process.

The silvering car was used in the installation of the mirror, as the figures indicate. The mirror was lifted vertically upward between the tube and the silvering car, by tackle attached by an eyebolt to a padded wooden block below the central hole. The silvering car was then rolled on its track directly under the mirror, which was let down on the timbers shown in Fig. 1. Three shorter pieces of 6 by 6 timber were cut, placed vertically on the frame of the silvering car, passing up between the ribs of the cell. The plunger was then run downwards until the mirror was supported on these three timbers. The tackle and horizontal timbers were removed and the cell raised by the plunger slowly and steadily into position about the mirror. The only risk involved in this process was the chance of accident with the tackle, and a very large factor of safety had been provided. After the mirror was placed in its cell, in proper position with regard to its counterweighted bottom and edge supports, it was only a matter of half an hour to attach it to the tube and, although every precaution against accident had been taken, every one concerned felt very much relieved when the mirror was finally in place and the telescope at last completed.

It was only a week after the mirror reached Victoria until it was installed, collimated, and the first star spectrum obtained, which is, I think, a record-breaking performance for such a large telescope. Even though the mounting had been erected and adjusted, still all the tackle had to be placed and attached, the Cassegrain silvered and collimated and the telescope rebalanced. I think it speaks volumes for the care used in the design and construction of the mounting and accessories, that there was no delay or hitch from any cause and that the telescope operated perfectly from the first without any alteration or further adjustment being required.

It was naturally a most interesting and yet somewhat anxious time not only during the installation, but in the first trial of the completed telescope; for, though every care had been taken in design, construction, and testing, yet it could not be definitely said whether the telescope would prove an unqualified or only partial success.

Then, too, the seeing conditions, though undoubtedly much superior to any other place tested, were only observed with a 4½-inch telescope and might fail to hold up under the much severer test of a 72-inch aperture and 108 ft. focal length, where it can be readily seen that poor seeing could easily give a very large and diffuse image.

Consequently it is a great satisfaction to be able to state that the performance of the optical parts, the mounting and the dome, and the character of the seeing, are quite equal to, and even exceed, expectations. Up to the present, the telescope has been regularly used only in the Cassegrain form with the spectrograph, which is shown in Fig. 4 attached to the lower end of the tube. The spectrograph is used now as a single prism instrument with a linear dispersion at $H\gamma$ of about 35 Å per mm., and gives excellent spectra of stars of photographic magnitude 7.0 under average seeing conditions in about 25 minutes. This will probably be improved considerably when the mirror is resilvered, as the present coat was put on in the Brashear works and is considerably damaged and tarnished.

The telescope is adapted for visual observations at the Cassegrain focus by inserting an auxiliary reflecting ocular adapter, which enables the image to be observed in a convenient position without removing the spectrograph. This is desirable, as the latter weighs about 1,000 lbs., and besides the trouble of removal, the balance of the instrument would be disturbed. It is this adapter which is used on Saturday evenings which, as at Ottawa, have been set aside for visitors to observe with the great reflector.

Although the diurnal range of temperature here is small, rarely exceeding 5°C, it is sufficient to introduce considerable aberration in the mirror. For example, Hartmann tests made after a day-time rise of about this amount showed a longitudinal aberration, under-correction, of nearly 3 mm., as compared with 0.25 mm. when tested under constant temperature. Consequently an insulating cover has been fitted to the lower end of the tube by which the temperature change around the mirror has been

reduced to about one-third that outside and the working figure thereby much improved. This cover and the experimental work connected therewith are, however, not yet completed and I will leave fuller description for another place. However, two or three preliminary photographs of clusters and nebulæ made at the Newtonian focus show very good images, a minimum diameter of about 1.5 seconds of arc, and it is certain, when the temperature conditions are improved, that these results will be bettered.

The mounting also is most convenient and accurate. The following is remarkably good, not a trace of the periodic irregularity so prevalent in telescopes generally, and it is necessary even with the focal length of 108 ft., to keep the image moving along the slit by the slow motions to prevent irregular density in the star spectrum of only about 0.3 mm. wide. The mechanism for setting to the star, including the electric quick and slow motions and the combined coarse-fine setting circles already described, work to perfection, and so long as the telescope has not to be reversed on the axis, and this is only seldom necessary, the time consumed in making the change from one star to another, that is, from the conclusion of the exposure on one spectrum to the beginning of that on another, is only from 4 to 5 minutes. Consequently spectra can be accumulated at a rapid rate, and 22 spectra of stars averaging fainter than 6.0 magnitude were obtained on one of these short summer nights in less than seven hours. Nearly 400 spectra have been obtained in two months observing, and it is evident that with the present small staff, the reduction will get woefully behind.

In short, we have been unable to see in the experience we have had in operating the telescope, how either optical parts, mounting, or dome could be improved, and I am satisfied that, for accuracy and convenience in operation, this installation is unexcelled.

Canada is to be congratulated on having obtained in so relatively short a time, and under such difficult and adverse conditions, such a splendidly efficient equipment for astronomical research. It is, however, not of much use to have a fine observatory unless

it is efficiently operated, and this depends upon the director and staff. At present, only Dr. R. K. Young, assistant astronomer, and the writer are available for carrying on the work. A largely increased staff is evidently necessary to operate this splendid instrument to capacity, but in the meantime it is hoped to make a fair showing and to lay substantial and secure foundations for the future work of the institution.

DOMINION ASTROPHYSICAL OBSERVATORY,
Victoria, B.C.,
July, 1918.

NOTES FROM THE METEOROLOGICAL SERVICE

Summary Report of the Weather in Canada

August, 1918

Temperature—The temperature was from average to 3° below over British Columbia, approximately the same amount below in Eastern Quebec and the Maritime Provinces, elsewhere in the Dominion it was above the average, but only to an appreciable quantity in Ontario, Parry Sound recording a positive departure of 4°, and Toronto 4°·6.

Precipitation.—The rainfall in British Columbia was well above the average amount. In the Western Provinces conditions were more varied, as whereas the greater portion of the Provinces received an excess rainfall, some few localities experienced very little. At Swift Current and Minnedosa the total fall was deficient by more than half-an-inch, while at Battleford the discrepancy was more than an inch. These conditions obtained very largely in Ontario, some localities, chiefly on account of heavy thunderstorms, recording much more rain than usual, others where the storms were not felt had a deficient rainfall. One of the most noticeable instances was that of Toronto, with 4·14 inches of rain, or 1·48 inches above the average, while Port Stanley and Kingston had 2·30 inches, which is well below the average quantity for these places. In Quebec and the Maritime Provinces the rainfall was everywhere below the average, and as a rule to a marked extent. The chief negative departures were 2·11 inches at Montreal, 2·02 inches at Anticosti, 2·50 inches at Chatham, 2·15 inches at Yarmouth, and 1·89 inches at Charlottetown.

Temperature for August, 1918

Station	August		Station	August	
	Highest	Lowest		Highest	Lowest
Yukon			Kenora	82	46
Dawson	70	28	Kinmount	97	34
British Columbia			Kingston	88	47
Atlin	70	36	Kitchener	101	43
Agassiz	86	35	London	106	45
Barkerville	74	32	Lucknow	99	38
Kamloops	88	44	Markdale	99	37
New Westminster	84	44	North Gower	95	35
Prince Rupert	78	48	Oshawa	96	42
Vancouver	79	47	Ottawa	93	44
Victoria	80	49	Paris	103	40
Western Provinces			Parry Sound	94	42
Battleford	89	38	Peterboro'	98	40
Calgary	93	34	Port Arthur	87	38
Edmonton	83	36	Port Burwell	85	45
Medicine Hat	96	41	Port Dover	95	46
Minnedosa	88	34	Port Stanley	86	45
Moose Jaw	94	41	Queensborough	93	40
Oakbank	90	40	Ronville	91	35
Portage la Prairie	90	41	Southampton	91	42
Prince Albert	84	40	Sundridge		
Qu'Appelle	86	40	Stonecliffe	94	36
Regina	88	38	Stony Creek	103	44
Saskatoon	88	39	Toronto	102	48
Souris	88	41	Uxbridge	96	39
Swift Current	96	51	Wallaceburg	104	46
Winnipeg	94	40	Welland		
Ontario			White River	83	28
Agincourt	100	45	*Quebec*		
Aurora	95	35	Brome	85	30
Bancroft	92	34	Father Point	78	40
Barrie	103	42	Montreal	86	46
Beatrice	92	33	Quebec	82	42
Bloomfield	93	45	Sherbrooke	89	35
Brantford	102	45			
Chapleau	82	30	*Maritime Provinces*		
Chatham	106	45	Charlottetown	88	40
Clinton	100	38	Chatham	86	42
Collingwood			Dalhousie		
Cottam	100	45	Fredericton	86	39
Georgetown	96	42	Halifax	84	40
Goderich	99	43	Moncton	86	34
Gravenhurst	96	39	St. John	80	46
Grimsby	101	47	Sussex	86	35
Guelph			Sydney	88	40
Haliburton	95	34	Yarmouth	77	40
Huntsville	92	34			

NOTES FROM THE METEOROLOGICAL SERVICE

Summary Report of the Weather in Canada
August, 1918

Temperature—The temperature was from average to 3° below over British Columbia, approximately the same amount below in Eastern Quebec and the Maritime Provinces, elsewhere in the Dominion it was above the average, but only to an appreciable quantity in Ontario, Parry Sound recording a positive departure of 4°, and Toronto 4°·6.

Precipitation.—The rainfall in British Columbia was well above the average amount. In the Western Provinces conditions were more varied, as whereas the greater portion of the Provinces received an excess rainfall, some few localities experienced very little. At Swift Current and Minnedosa the total fall was deficient by more than half-an-inch, while at Battleford the discrepancy was more than an inch. These conditions obtained very largely in Ontario, some localities, chiefly on account of heavy thunderstorms, recording much more rain than usual, others where the storms were not felt had a deficient rainfall. One of the most noticeable instances was that of Toronto, with 4·14 inches of rain, or 1·48 inches above the average, while Port Stanley and Kingston had 2·30 inches, which is well below the average quantity for these places. In Quebec and the Maritime Provinces the rainfall was everywhere below the average, and as a rule to a marked extent. The chief negative departures were 2·11 inches at Montreal, 2·02 inches at Anticosti, 2·50 inches at Chatham, 2·15 inches at Yarmouth, and 1·89 inches at Charlottetown.

Temperature for August, 1918

Station	August		Station	August	
	Highest	Lowest		Highest	Lowest
Yukon			Kenora	82	46
Dawson	70	28	Kinmount	97	34
British Columbia			Kingston	88	47
Atlin	70	36	Kitchener	101	43
Agassiz	86	35	London	106	45
Barkerville	74	32	Lucknow	99	38
Kamloops	88	44	Markdale	99	37
New Westminster	84	44	North Gower	95	35
Prince Rupert	78	48	Oshawa	96	42
Vancouver	79	47	Ottawa	93	44
Victoria	80	49	Paris	103	40
Western Provinces			Parry Sound	94	42
Battleford	89	38	Peterboro'	98	40
Calgary	93	34	Port Arthur	87	38
Edmonton	83	36	Port Burwell	83	45
Medicine Hat	96	41	Port Dover	95	46
Minnedosa	88	34	Port Stanley	86	45
Moose Jaw	94	41	Queensborough	93	40
Oakbank	90	40	Ronville	91	35
Portage la Prairie	90	41	Southampton	91	42
Prince Albert	84	40	Sundridge		
Qu'Appelle	86	40	Stonecliffe	94	36
Regina	88	38	Stony Creek	103	44
Saskatoon	88	39	Toronto	102	48
Souris	88	41	Uxbridge	96	39
Swift Current	96	51	Wallaceburg	104	46
Winnipeg	94	40	Welland		
Ontario			White River	83	28
Agincourt	100	45	*Quebec*		
Aurora	95	35	Brome	85	30
Bancroft	92	34	Father Point	78	40
Barrie	103	42	Montreal	86	46
Beatrice	92	33	Quebec	82	42
Bloomfield	93	45	Sherbrooke	89	35
Brantford	102	45			
Chapleau	82	30	*Maritime Provinces*		
Chatham	106	45	Charlottetown	88	40
Clinton	100	38	Chatham	86	42
Collingwood			Dalhousie		
Cottam	100	45	Fredericton	86	39
Georgetown	96	42	Halifax	84	40
Goderich	99	43	Moncton	86	34
Gravenhurst	96	39	St. John	80	46
Grimsby	101	47	Sussex	86	35
Guelph			Sydney	88	40
Haliburton	95	34	Yarmouth	77	40
Huntsville	92	34			

MAGNETIC OBSERVATIONS

June and July, 1918

During the month of June the Magnetic Forces were very steady except from the 10th to the 17th. During this period there was a moderately active disturbance, which during the night hours of each day caused a diminution of both H and Z and some moderately large deflections in D at Agincourt.

At Meanook deflections in D were very rapid and of large amplitude during the nights and early mornings and particularly so on the night of June 10th.

During July there were no noteworthy disturbances. Moderate ones were recorded on July 11 and 28 to 31, but during the rest of the month the Magnetic Forces were comparatively quiet.

The sun's surface was much spotted from the 1st to 10th of June and from June 28 to July 31.

The Aurora was only recorded in a few places during June and July, and in these few days was seen from June 7 to 14, July 7 to 12 and July 27 to 30.

AGINCOURT MAGNETIC OBSERVATIONS

Lat. 43° 47′ N.; Long. 79° 16′ W.

June, 1918		D. West	H	Z	I
		° ′	γ	γ	° ′
	Mean of Month	6 37·8	15929	58360	74 44·0
	Maximum	7 21·5	16089	58469	
	Date of Maximum	11	10	10	
	Minimum	5 57·4	15588	58121	
	Date of Minimum	9	10	10	
	Monthly Range	1 24·1	501	348	
Mean Daily Amplitude	From hourly readings	13·3	59	25	
	From means of extremes	23·1	99	59	

MEANOOK MAGNETIC OBSERVATIONS

Lat. 54° 37′ N.; Long. 113° 21′ W.

June, 1918		D. East	H	Z	I
		° ′	γ	γ	° ′
	Mean of Month	27 44·2	12948	60370	77 53·7
	Maximum	29 25·6			
	Date of Maximum	10			
	Minimum	26 03·8			
	Date of Minimum	10			
	Monthly Range	3 21·8			
Mean Daily Amplitude	From hourly readings	17·0			
	From means of extremes	40·3			

H and Z are given in Gammas. (1 γ = 0·00001 C.G.S.).

All results are reduced to International Magnetic Standard.

The value for I at Meanook is the mean of all the observations made during the month without regard to the time of day.

The value of H at Meanook is the mean of two observations made about the middle of the month, and the Z is obtained by the formula $Z = H \tan I$.

AGINCOURT MAGNETIC OBSERVATIONS

Lat. 43° 47′ N.; Long. 79° 16′ W.

July, 1917		D. West	H	Z	I
		° ′	γ	γ	° ′
	Mean of Month	6 37·3	15926	58348	74 44·0
	Maximum	6 56·6	16077	58491	
	Date of Maximum	30	28	28	
	Minimum	6 05·1	15806	58222	
	Date of Minimum	28	28	30	
	Monthly Range	51·5	271	269	
Mean Daily Amplitude	From hourly readings	15·4	56	28	
	From means of extremes	22·8	90	54	

MEANOOK MAGNETIC OBSERNATIONS

Lat. 54° 37′ N.; Long. 113° 21′ W.

July, 1917		D. East	H	Z	I
		° ′	γ	γ	° ′
	Mean of Month	27 43·6	12915	60217	77 53·7
	Maximum	28 59·0			
	Date of Maximum	29			
	Minimum	27 05·1			
	Date of Minimum	7			
	Monthly Range	1 53·9			
Mean Daily Amplitude	From hourly readings	17·7			
	From means of extremes	34·3			

H and Z are given in Gammas. (1 γ = 0·00001 C.G.S.).

All results are reduced to I.M.S.

The value of I at Meanook is the mean of all the observations made during the month without regard to the time of day.

The value of H at Meanook is the mean of two observations made about the middle of the month, and the Z is obtained by the formula Z = H tan I.

W. E. W. J.

Earthquake Records by the Milne Seismograph

TORONTO

Sir Frederic Stupart, Director.

P. T. = Preliminary Tremors. S. = Secondary Waves. L.W. = Large Waves. A.C. = Air Currents. Time is Greenwich Civil Mean Time, 0 or 24 h = midnight.

No.	Date 1918		P. T. Comm.	S. Comm.	L.W. Comm.	Max.	End	Max. Amp.	Remarks
			h m	h m	h m	h m	h m	mm	
1884	Aug.	5			2 42·0?	?	?		Micros masked phases.
1885	"	8		10 25·4?	10 48·0 10 49·1	10 59·3	12 59·4?	1·2	
1886	"	15	12 37·5? 12 39·8	12 51·4 12 55·2	12 58·0 13 02·1	13 39·6	?	14·4	F merged into next quake.
1887	"	15			17 51·9	18 59·1	20 06·1?	0·3	
1888	"	16			9 20·7			0·05	Doubtful as to being seismic.
1889	"	17			7 31·6	7 41·7	Micros.	0·2	
1890	"	21			4 14·4	4 14·6	Micros.		Doubtful as to being seismic
1891	"	22			8 42·3		8 47·6	0·05	Doubtful as to being seismic.
1892	"	23	7 01·2? 7 05·9	7 12·9	7 17·1 7 35·6	7 47·4	10 10·0?	2·3	Micros at 6h-55'5m.

August 4th--Light off. Quake 16h 21m at some stations.

Boom period 18 seconds. Pillar inclination 1mm. = 0."45.

VICTORIA, B. C.

F. N. DENISON, SUPERINTENDENT.

No.	Date 1918	P.T. Comm.	S. Comm.	L.W. Comm.	Max.	End	Max. Amp.	Remarks
		h m s	h m s	h m s	h m s	h m s	mm	
1883	Aug. 5	2 12 58?	2 19 51	2 29 01	2 35 35	3 01 39?	0·3	5,200 km.
1884	" 8	10 11 45	10 17 39	10 19 57	10 41 45	12 27 29	1·5	4,120 km.
1885	" 15	12 32 18	12 43 36	12 55 24 12 58 21	13 23 27	17 10 10	9·0	10,440 km. Prob in vicinity Malay Archipelago,
1886	" 15	17 55 54	18 06 47	18 17 03	18 42 37	19 11 09?	0·4	9,890 km.
1887	" 16	?	9 22 54		9 38 47	?	0·1	S. may be L.
1888	" 17			7 43 40	7 45 28	7 47 20	0·1	
1889	" 23	6 59 31	7 05 26	7 15 45	7 27 06	9 36 24	4·0	4,140 km. Western part Aleutian Islands?

Boom period 18 seconds. Pillar inclination 1mm. = 0″·54

VERTICAL SEISMOGRAPH

Date 1918	P.T. Comm.	S. Comm.	L.W. Comm.	Max.	End	Max. Amp.	Remarks
	h m s	h m s	h m s	h m s	h m s	μ*	
Aug. 8	10 11 54	10 17 39	10 29 30	10 34 30	?	4	4330 km.
" 15	12 32 18	12 44 30	13 04 30	13 06 18	?	18	11,770 km.
" 22			15 21 35			1	Local†

*True earth movement.

†Lasted 1 sec. preceded by a rumbling noise from S. W. Felt at Victoria Observatory and in rocky parts of city, causing articles to rattle. Probably under Strait of Fuca.

ASTRONOMICAL NOTES

SOLAR MOTIONS AND STAR STREAM MOTIONS.—In previous determinations of the motion of the sun in space and of the star streams the stars have been divided for discussion according to spectral type or apparent magnitude. The recent investigations of Adams and Strömberg have shown that the intrinsically faint stars have a higher average radial velocity than those that are intrinsically brighter, or in other words, that radial velocity is a function of absolute magnitude. Accordingly an investigation of the solar motion and the stream motion based upon a division of stars into groups of nearly equal absolute magnitude is of exceptional interest, since the dispersion of the radial velocities within each group is considerably less than in the usual case.

In accordance with the method of Charlier, the sky has been divided into 48 equal areas situated symmetrically with reference to the galactic equator. If star streaming is studied on the basis of the ellipsoidal or the two drift theory, opposite areas may be combined by assuming that the stream motion is the same in all parts of the space.

Since the sun, however, is not situated at the centre of the stellar system, but at a distance from it probably comparable with the mean distance of the later type stars used in this investigation, we might, according to the theory of Turner and Eddington, conceive the stream-motion to be due to the general attraction of the stellar system. It would then differ from point to point and be related to the position of the centre and the central

plane of the stellar system. Such a theory is supported by Kapteyn's suggestion that there is an acceleration of the first stream; *i.e.*, that the velocity of the first stream is different in different parts of the space.

In order to test for the existence of such a varying stream-motion, I have tried to express the average radial velocity as a rational integral function of the direction-cosines of the line of sight such that the radius vector of the surface thus defined equals the average radial velocity. Using only terms of second order we can in this way determine the stream-motion, if the latter is constant (Eddington). If the stream motion is variable this must be marked by the existence of asymmetrical (odd) terms in the analytical representation of the surface.

According to Charlier the position of the centre as derived from 800 B-type stars is

$l = 236°$ $b = -14°$ Distance = 88 parsecs.

O. R. Walkey finds from 30736 stars of all types the longitude $l = 246°$. These values of the galactic longitude of the centre of the stellar system are in fair agreement with the value 258° found for the position of the symmetrical plane. We may, therefore, conclude that the variation of average radial velocity with direction is due probably to a motion of the stars around the centre of the galactic system. Moreover, if the stars are moving around the centre of the stellar system we should expect a minimum orbital velocity near the centre and a maximum at a certain distance from the centre. The minimum in radial velocity near longitude 268° is in agreement with this conclusion.

In the case of the stars nearest to us, we should expect the axes of preferential motion to lie nearly in a straight line, since their distance from us is small as compared with their distance from the centre. To test this question I have made an analysis of the radial velocities of the stars in Group, which contains the nearest stars, combining all stars between galactic latitude $-66°$ and $+66°$. The axes of maximum radial velocity for the resulting curve have the longitudes 157° and 340°, which thus differ by 183°. The longitude of the axis of symmetry is 254°,

a value in good agreement with that found for the more distant stars. The intersection of the surface with the galactic plane is shown.

The conclusion to be drawn from these results is that stream motion is probably a local effect caused by a preferential motion of the stars in both directions around the centre of the stellar system. This might have been expected from the fact that the motions of the two 'drifts' have been found to be in the galactic plane and at right angles to the direction of the centre of the galaxy. The deviation of the axes of preferential motion from a straight line furnishes strong evidence in support of this conclusion.—G. STROMBERG, Communication from the Mount Wilson Observatory, to the *National Academy of Sciences*, No. 52.

THE BLUE OF THE SKY.—It is now well established that the luminosity and blue color of the sky on very clear days and at considerable altitudes above the sea-level can almost be accounted for by the scattering of light by the molecules of air, without postulating suspended particles of foreign matter, such as were thought necessary by the earlier writers.

This conclusion depends on the measured opacity of the atmosphere, deduced from observations such as those of Abbot and Fowle of the sun's radiation at various zenith distances. The opacities measured at Mount Wilson for different wavelengths are found to be nearly in agreement with what would be expected if scattering by the molecules were alone operative; leaving little room for the action of larger particles.

I have not been able to find any reference in the later literature to the possibility of observing in the laboratory the scattering of light by pure air, filtered free from dust. Tyndall, who devoted more attention to such questions than any other experimenter of his day, states that nothing of the kind can be observed. He says; "I, at that time (1872), found that London air, which is always thick with motes, and also with matter too fine to be described as motes, after it had been filtered by passing through densely packed cotton wool . . . . showed, when examined by a

concentrated luminous beam, no trace of mechanically suspended matter. The particular portion of space occupied by such a beam was not to be distinguished from adjacent space." "The purely gaseous portion of our atmosphere was thus shown to be incompetent to scatter light," and as far as I have been able to learn it has generally been supposed, perhaps in view of Tyndall's statement just quoted, that very great thicknesses of air would have to be illuminated before the scattered light would be appreciable. Certainly such was my own notion.

I was first led to question this by noticing that the search-lights used for anti-aircraft purposes, both in town and country, always exhibit a distinct scattering along their track, even on the clearest nights, and high above the ground level. When the air is very clear, the track of the beam is comparatively faint, and of a bluish color. But it is always perfectly easy to see. This, though suggestive, does not, of course, definitely prove that the observed scattering is independent of dust.

The following simple considerations show, however, that the scattering of light by pure air should be within the range of laboratory experiment.

The brightness of the clear sky in sunlight may be estimated at 550,000 times its value in full moonlight, since that is the comparative photometric value of the sun and the moon. If, instead of 5 miles "of homogeneous atmosphere" illuminated by the sun, we substitute a layer 1/550000th part of this, or 0·58 inch thick, the intensity should be equal to that of the moonlit sky. It is easy to arrange conditions at least as good as this in the laboratory, whether sunlight or arc-light is used; and, therefore, the scattered light, like the light of the moonlit sky, should be quite bright enough for observation.

In arranging an experiment for this purpose, the chief essential was to avoid as far as possible stray light diffused from the wall of the vessel used, and to observe the beam transversely against the blackest possible background.

All the results here described are in qualitative agreement with the received theory of scattering. Quantative measurements are in progress.

Summary.—(1) By proper arrangement of the experimental conditions it is possible to observe the scattering of light by pure air, free of dust, in a small-scale laboratory experiment.

(2) Similar results can be obtained with other gases. Hydrogen gives much less scattering than air, oxygen about the same, carbon dioxide decidedly more.

(3) The scattered light in air and in all the other gases is blue—the blue of the sky, illustrating very directly the theory that attributes the blue of the sky to scattering by the molecules of air.*

(4) The scattered light is almost completely polarized.—Hon. R. J. Strutt, *Proceedings of the Royal Society*, Series A. Vol. XCIV.

The Origin of Comets.—In an article which appears in the August issue of *Scientia* (Vol. XXIV., p. 85), Professor E. Strömgren gives an interesting account of the reasons for regarding comets as permanent members of the solar system. In recent years exact calculations have shown that comets which have appeared to traverse hyperbolic orbits, when in the neighborhood of the sun, acquired the hyperbolic form in consequence of the perturbations to which they were subjected by the planets. It is accordingly concluded that comets belong to our system, and that the so-called non-periodic comets are merely comets which have very long periods. The possibility of a comet entering our system from without is not excluded, but it is stated that no case of this kind is yet known. By reference to the dynamics of star-clusters it is argued that, while remnants of nebulous matter would, in general, be retained within the systems formed by individual suns, those which originally occupied the intermediate spaces would escape from the galactic system on account of the high velocities corresponding with their small masses. On this view, comet-forming materials would not exist in interstellar space.—*Nature*, August, 1918. J. R. C.

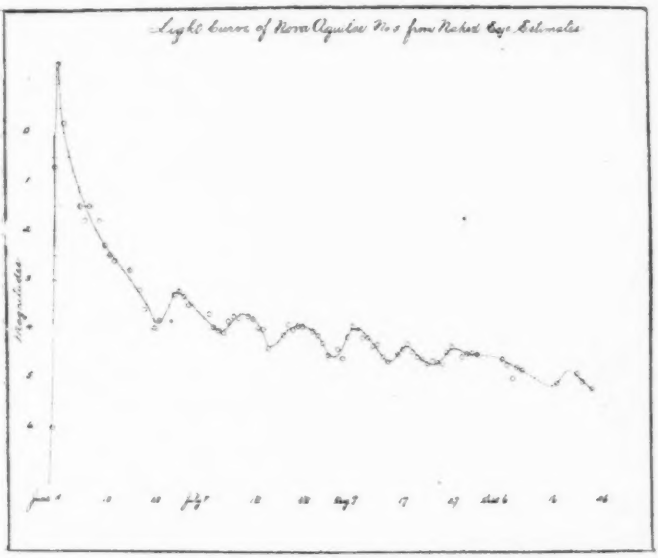
*Tyndall obtained the blue by means of fine-grained fogs, precipitated from organic vapors. This was a valuable contribution, but his fogs were of course both chemically and physically very different from dust-free air.

NOTES AND QUERIES

Communications are Invited, Especially from Amateurs. The Editor will try to Secure Answers to Queries.

NOVA AQUILÆ NO. 3; ITS VISUAL LIGHT-CURVE

The accompanying light-curve of Nova Aquilæ No. 3 is from naked-eye estimates made since June 10 by members of the Dominion Observatory staff, Messrs. Stewart, DeLury and W. E. Harper and by Major J. A. Pearce, of Rockcliffe Camp, a



LIGHT-CURVE OF NOVA AQUILÆ NO. 3, FROM NAKED EYE ESTIMATES AT DOMINION OBSERVATORY, OTTAWA

returned soldier, who discovered the nova independently on the early evening of June 9th. Naturally the curve is only approximate and a comparison with the provisional one issued by Harvard (see Plate XIII.) shows that these estimates on the average place the star fully 0·1 magnitude fainter than that given by the Harvard curve. Nevertheless the general trend of the curve is correct and it has been used by Mr. Harper in comparing the oscillations in brightness with the changes in the spectrum. During July every increase in brightness was accompanied by the return of the continuous spectrum which in turn faded as the star diminished in brightness. As Professor Pickering has expressed it in the case of Nova Persei No. 2, the spectrum at a maximum is "normal" while at a minimum it is "peculiar." Other corresponding features will be dealt with in a forthcoming article by Mr. Harper.

THE OMISSION OF THREE CIPHERS

In another part of this issue is the closing chapter of the production and installation of the great reflecting telescope at Victoria, B.C. When the 72-inch mirror, after long and anxious labor, had been at last completed and had been found to fulfil the severe conditions of the contract, it was natural that the Pittsburgh newspapers should give some account of the splendid achievement. Dr. Brashear relates that one paper in referring to the accuracy of the figure of the mirror stated that its form did not vary 1/400th of an inch from the calculated value. As a matter of fact it was not more than 1/400,000th of an inch from the shape aimed at. This is an indication of the small quantities that the maker of optical instruments has to deal with.

A NEW VARIABLE STAR OF SHORT PERIOD

In Harvard *Circular*, No. 117, is explained a method of discovering variable stars of short period. It consists in taking a photograph of a portion of the sky, displacing the plate slightly every half hour or thereabouts. In this way is obtained a row

of images of each star, perhaps ten in number, and if during the entire time of exposure the brightness of a star in the field has varied it will be betrayed by the inequality of the images. Recently Miss F. Mabel Ashall, M.A., while pursuing graduate study at the University of Toronto, examined a number of plates placed at her service by Director Pickering, of Harvard College Observatory, and was fortunate in discovering a new variable in Andromeda, R.A. $22^h\ 49^m{\cdot}1$, Dec. + 37° 23′ (1900). The range of variation is not great being from approximately 9·18 to 9·88 mag., but the star is remarkable on account of its period being very short, namely $3^h\ 50^m\ 55^s{\cdot}10$. In Harvard *Circular*, No. 207, Miss Henrietta S. Leavitt gives an account of her examination of numerous photographs on which the star is shown, taken during the last 26 years. She found that during 1913 the period changed suddenly, becoming longer by $0^s{\cdot}17$. The light-curve shows a gradual decline in brightness and a similar gradual increase, with no evidence of a secondary minimum.

TESTIMONIAL TO MR. MILLER

Recently there was tendered to the President of our Society, Mr. A. F. Miller, a marked expression of esteem. For forty-three years he has been connected with the Toronto General Hospital, much of the time as secretary of the Board of Trustees; and upon his resignation from that position he was presented by the Board with a fine silver service as a token of the high regard in which he is held by the directing heads of the institution.

The presentation took place in the Mayor's office at the City Hall, and was attended by the Hospital Board of Trustees, the Mayor and the Board of Control, and other close friends. Sir Joseph Flavelle, chairman of the Board, addressing Mr. Miller said:

> Your life for forty-three years has been given to the hospital. You have loved it; you have lived for it; you have served it with devotion and faithfulness. It was your courage and determination which preserved for the endowment fund the lands owned by the trust, and it was through your prudence and pertinacity

that these properties were preserved. The soundness of your judgment is seen in the annual revenue, now exceeding $50,000, received from the rentals of these properties.

The penalty of years has made it necessary for you to give up your position as secretary of the trust, but the board continues to have your invaluable services in the administration of its properties. The trustees ask you to accept from them personally this service of silver as an expression of appreciation of these long years of unremitting work and for your loyal support of successive boards of trustees.

A photograph of the handsome present is shown in the accompanying engraving. The inscription on the plate reads:

This service presented to Allan Frederick Miller by the Trustees of the Toronto General Hospital as an evidence of high and sincere regard in recognition of forty three years of service to the hospital, during which time his devoted care to its financial interests aided the Trustees in extending its beneficial work, July 24, 1918.

During the past forty years Mr. Miller devoted a good deal of time to practical astronomy, using various telescopes, one a With-Browning reflector of 10¼ inches aperture with which he made many drawings of the planets, and observations of double stars, nebulæ and similar objects. But the instrument he chiefly used is a 4-inch refractor by Wray, equatorially mounted and provided with solar and stellar spectroscopes, micrometer and other adjuncts. Readers of the JOURNAL may remember his contributions to the Society's publications in former years, among which might be mentioned a summary of his work on "Nova Persei 1901," as well as other papers, though he generally preferred to publish only by title. During the past six years his official duties obliged him practically to give up astronomical work. However he expects soon to have leisure which will permit him again to give attention to the special branches of astronomy and physics in which he has long been interested. His recent contribution to the JOURNAL, entitled "Observing Mars with a Small Telescope," is a first step in that direction, and he will shortly contribute a paper on "Nova Aquilæ," giving an account of his spectroscopic and other observations of this wonderful object since its appearance on the 8th of June last.

C. A. C.

SERVICE OF SILVER PRESENTED TO MR. A. F. MILLER

SOLAR PROMINENCE

Photographed by Mt. Wilson Observatory Expedition at Green River, Wyoming, during Total Eclipse of June 8, 1918.
(From *Pub. A.S.P.*, August, 1918).
(Compare Fig. 1, Plate XIII.)

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